

## CLAIMS

- 1           1.       An output stage for providing a substantially symmetrical rail-to-rail output  
2       voltage, the output stage comprising:
  - 3           a first field effect device having a first source, first drain, and first gate, the first  
4       source being coupled to a power supply  $V_{CC}$ ;
  - 5           a second field effect device complementary to the first field effect device, wherein the  
6       second field effect device includes a second source, second drain, and second gate, and  
7       wherein the second source is coupled to a power supply having a nominal voltage supply of  
8        $V_{EE}$  and wherein the second drain is coupled to the first drain; and  
9           an output sink network coupled to the second gate, wherein the output sink network  
10       drives the second field effect device such that a product of a first current in the first field  
11       effect device and a second current in the second field effect device is substantially equal to a  
12       predetermined constant.
- 1           2.       An output stage as recited in claim 1, wherein a sum of the first current and  
2       the second current is essentially equal to a predetermined constant during operation of the  
3       output stage.
- 1           3.       An output stage as recited in claim 1, wherein the first field effect device is  
2       configured in a common source configuration.
- 1           4.       An output stage as recited in claim 1, wherein the first field effect device is a  
2       P-channel metal oxide semiconductor field effect (PMOS) transistor.
- 1           5.       An output stage as recited in claim 4, wherein the second field effect device is  
2       an N-channel metal oxide semiconductor field effect (NMOS) transistor.
- 1           6.       An output stage as recited in claim 5, wherein the output sink network utilizes  
2       a current mirror to track the current in the first field effect device.

1           7.     An output stage as recited in claim 6, wherein the current mirror tracks the  
2     current in the first field effect device at a predetermined ratio of the current in the first field.

1           8.     An output stage as recited in claim 1, wherein the first field effect device is an  
2     N-channel metal oxide semiconductor field effect (NMOS) transistor.

1           9.     An output stage as recited in claim 8, wherein the second field effect device is  
2     a P-channel metal oxide semiconductor field effect (PMOS) transistor.

1           10.    An output stage as recited in claim 1, wherein a substantially rail-to-rail output  
2     voltage produced by the output stage is no more than one  $V_{GS}$  and two  $V_{Dsat}$  from either rail.

1           11.    A method for providing an output signal from an output stage of a low voltage  
2     operation amplifier capable of providing a substantially rail-to-rail output voltage, the method  
3     comprising the operations of:

4                 providing an input signal to a first field effect device having a first source, first drain,  
5     and first gate, the first source being coupled to a power supply  $V_{CC}$ ; and

6                 driving a second complimentary field effect device utilizing an output sink network  
7     such that a product of a first current in the first field effect device and a second current in the  
8     second field effect device is substantially equal to a predetermined constant.

1           12.    A method as recited in claim 11, wherein a sum of the first current and the  
2     second current is essentially equal to a predetermined constant during operation of the  
3     amplifier.

1           13.    A method as recited in claim 11, wherein the first field effect device is  
2     configured in a common source configuration.

1           14.    A method as recited in claim 13, wherein the first field effect device is a P-  
2     channel metal oxide semiconductor field effect (PMOS) transistor.

1           15.     A method as recited in claim 14, wherein the second field effect device is an  
2 N-channel metal oxide semiconductor field effect (NMOS) transistor.

1           16.     A method as recited in claim 15, further comprising the operation of tracking  
2 the current in the first field effect device utilizing a current mirror.

1           17.     A method as recited in claim 16, wherein the current mirror tracks the current  
2 in the first field effect device at a predetermined ratio.

1           18.     A method as recited in claim 11, further comprising the operation of  
2 producing an essentially rail-to-rail output voltage, the essentially rail-to-rail output voltage  
3 being no more than one  $V_{GS}$  and two  $V_{Dsat}$  from either rail.

1           19.     An application specific integrated circuit (ASIC) having an output stage for a  
2 low voltage operational amplifier, the ASIC comprising:

3                 a first field effect device having a first source, first drain, and first gate, the first  
4 source being coupled to a power supply  $V_{CC}$ ;

5                 a second field effect device complementary to the first field effect device, wherein the  
6 second field effect device includes a second source, second drain, and second gate, and  
7 wherein the second source is coupled to a power supply having a nominal voltage supply of  
8  $V_{EE}$  and wherein the second drain is coupled to the first drain; and

9                 an output sink network coupled to the second gate, wherein the output sink network  
10 drives the second field effect device such that a product of a first current in the first field  
11 effect device and a second current in the second field effect device is essentially equal to a  
12 predetermined constant during operation of the output stage.

1           20.     An ASIC as recited in claim 19, wherein the first field effect device is  
2 configured in a common source configuration.

1           21.     An ASIC as recited in claim 19, wherein the first field effect device is a P-  
2 channel metal oxide semiconductor field effect (PMOS) transistor.

1           22.     An ASIC as recited in claim 21, wherein the second field effect device is an  
2 N-channel metal oxide semiconductor field effect (NMOS) transistor.

1           23.     An ASIC as recited in claim 22, wherein the output sink network utilizes a  
2 current mirror to track the current in the first field effect device.

1           24.     An ASIC as recited in claim 23, wherein the current mirror tracks the current  
2 in the first field effect device at a predetermined ratio. A method as recited in claim 13,  
3 wherein the current mirror tracks the current in the first field effect device at a predetermined  
4 ratio.

1           25.     An ASIC as recited in claim 24, wherein the predetermined ratio is about 6:1.

1           26.     An ASIC as recited in claim 19, wherein a substantially rail-to-rail output  
2 voltage produced by the output stage is no more than one  $V_{GS}$  and two  $V_{Dsat}$  from either rail.

1           27.     An operational amplifier output stage suitable for low voltage operation and  
2 capable of providing a substantially rail-to-rail output voltage, the output stage comprising:

3                 a push-pull output network, wherein the push-pull output network receives a first  
4 input signal and a second input signal, the first input signal being provided by an input signal  
5  $V_{IN}$ ; and

6                 an output sink network, wherein the output sink network provides the second input  
7 signal to the push-pull output network.

1           28.     An operational amplifier output stage as recited in claim 27, wherein the push-  
2 pull output network includes a first field effect device and a second complimentary field  
3 effect device.

1           29.     An operational amplifier output stage as recited in claim 28, wherein the first  
2 field effect device is configured in a common source configuration.

1           30.    An operational amplifier output stage as recited in claim 29, wherein the  
2   output sink network utilizes a current mirror to track the current in the first field effect  
3   device.

1           31.    An operational amplifier output stage as recited in claim 30, wherein the  
2   current mirror tracks the current in the first field effect device at a predetermined ratio.

1           32.    An operational amplifier suitable for operating on low input voltages and  
2   capable of providing a substantially symmetrical rail-to-rail output voltage, the operational  
3   amplifier comprising:

4           an input stage; and

5           an output stage coupled to the input stage, wherein the output stage includes an output  
6   sink network.

1           33.    An operational amplifier as recited in claim 32, wherein the output stage  
2   further includes a push-pull output network, wherein the push-pull output network receives a  
3   first input signal and a second input signal, the first input signal being provided by an input  
4   signal  $V_{IN}$ .

1           34.    An operational amplifier as recited in claim 33, wherein the output sink  
2   network provides the second input signal to the push-pull output network.